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Nummi valent: Et multa danda esse tempori et consuetudini. Sicut enim non necesse est, illa moneta hodie uti, qua olim majores nostri usi sunt, quæque usu hodie exolevit; imo sicut moneta antiqua hodie interdum est sine usu, et pro κειμηλίῳ potius ac monimento antiquitatis reponitur, quam pro usu erogatur: Ita etiam non necesse est, vel Verbis antiquis quæ usus abolevit, vel Pronunciatione antiqua jam abolita denuo uti velle, imo ea quæ exoleverunt, non tam sunt hodie superstitiose et ambitiose usurpanda, quam cum judicio notanda et observanda; usumque Vulgo concedere, scientiam nobis reservare debemus, ut ait Cicero. Quin potius *Moribus antiquis: præsentibus utere verbis.*

ART. VIII.—*The Elements of Chemical Science. By John Gorham, M. D. Member of the American Academy, and Professor of Chemistry in Harvard University, Cambridge. Homo naturæ minister et interpres.—Bacon. Vol. I.* pp. 556. Boston, Cummings & Hilliard, 1819.

THE rapid improvements which have been made in the science of chemistry during the present century, have rendered it almost impossible for any to keep pace with it in its discoveries and revolutions, except those who have made it a particular object of attention. Never before, probably, have the exertions of so many individuals of the highest capacities and most persevering industry been at once concentrated upon a single subject; or the zeal and ardour of the philosopher been so entirely seconded by liberality and patronage. Chemistry has been the most popular science of the age. The novelty and splendour of some of its discoveries, the almost magical effect produced by some of its operations, and the readiness with which it explains so many of the ordinary phenomena of nature, have served to attract and charm minds but little disposed to relish its deeper investigations. This was particularly the case, whilst the theory of Lavoisier continued to be received in the chemical world. Its beauty and simplicity, the facility with which it was explained and understood, and its almost perfect applicability in accounting for the operations of nature, recommended it to the attention of general observers, as well as the philosophical inquirer. But the revolutions which in the course of a few years have been effected with regard to some of its most important principles, by rendering chemistry more complicated and abstruse, have lessened very much the fascinations which it formerly possessed. It is now no easy matter—such has been the progress of discovery—to comprehend perfectly the refined speculations of the science, or the new arrangements and relations which have been pointed out in the different forms of matter, by recent investigations. A tolerable knowledge of chemistry cannot now, as it could once, be obtained by attending a few lectures, performing a few experiments, and studying some short and familiar exposition of its principles. It has now assumed somewhat of a more repulsive appearance. Such indeed are the changes which have taken place, that those elementary works which were in common use, have become obsolete; or been mutilated and disjointed by the unskilful incorporation of new discoveries.

Dr. Gorham has performed a valuable service to the University with which he is connected, and to the public at large, in the task he has undertaken; and which he has so far accomplished with great accuracy, industry and ability. We have been much in want of a book of the kind he has presented to us, which should afford a general, but at the same time, accurate and scientific view of the subject, without entering into those minuter details of practice, which are dry and revolting to all but the professional student. Upon the general principles of the science, upon those points particularly, which are applicable to the phenomena of the external world, with which we are most conversant, we are presented with full and ample discussions; whilst upon those which relate chiefly to the operations of the laboratory, and the manipulations of the practical chemist, the author has taken a narrower range, and confined himself to the most essential particulars.

In systems of chemistry the synthetic method has been most frequently adopted; though it has been often doubted, whether the analytic may not be better adapted to convey a knowledge of its principles.

'In a work of this kind,'—says Dr. Gorham,—'a refined and complicated system is not necessary. The plan which has been adopted is simple, and such as appeared to the author the best calculated to present to the reader in a natural order the series of connected facts. In elementary works, he believes that it is most expedient to commence with the general principles of the science, and in illustrating the doctrines of chemistry, it is not necessary that the reader should be intimately acquainted with the bodies by which these doctrines are to be demonstrated. The subjects, therefore, in the following pages have been divided into two parts. The first part is devoted to the general laws of the science, and to the properties and modes of action of the powers or agents which are concerned in the production of chemical phenomena. In the second part are detailed the properties and relations of ponderable bodies and their compounds.' *Pref.* p. x.

The method adopted by Dr. Gorham we believe to be more unexceptionable, than that of works upon chemistry in general. Yet we conceive, that for the majority of readers, the best method of instruction would be, to follow, as nearly as possible, the course which the mind takes in investigating. The synthetical arrangement, strictly carried into effect, must, it appears to us, be completely unintelligible except to an adept in the science. It is certainly desirable in the acquisition of all learning, that we should go through the same processes of mind in studying the observations or discoveries of another, as if we had made them ourselves. We should, as far as possible, teach, or seem to teach ourselves. That which we have discovered by our own exertions is most firmly impressed upon our minds; and the same, though in a less degree, is true, if we follow the steps of the discoveries of another. By pursuing a train of investigation, we make it our own; and the impression of a fact thus acquired is far more lively and permanent, than if we retained it singly in our memory; because in the former case, it is connected with a train of associated ideas, by which it is more easily recalled into the mind, than if it stood insulated and alone. Who does not receive a clearer notion of the relations of oxygen to the metallic oxides, from an acquaintance with the precise and logical experiments of Lavoisier, than he would from a dry detail of the simple matter of fact? And although it would be impossible to enter into minute analyses and histories of experiments in an elementary work; yet the general method is possessed of similar advantages; and it is for this we contend.

There are two classes of persons who pursue the study of chemistry—and indeed the same is true of every other science—those who wish merely to acquire such a knowledge of its principles and operations, as will enable them to understand the constitution and relations of the objects about them, and the causes of the different phenomena in the external world;—these study only the chemistry of nature;—and those who follow it professionally, who have more regard to its practical details and manipulations, than to its connexion with the operations of nature. These, if we may so speak, study principally the chemistry of the laboratory. Now there ought to be a great difference in the modes of instruction, where the objects to be attained are so different; and there is perhaps no question, that the synthetic method is best adapted for the education of the professional chemist. He should study the science before he studies nature; and become master of its artificial and technical forms, before he applies them to the elucidation of any thing out of his laboratory. He should become familiar with the effects and changes wrought by his retort and crucible, before he would penetrate into the mysterious secrets of the air, the earth, and the ocean. But the opposite method seems, as we have intimated, better fitted for the purposes of the general scholar, who seeks only knowledge enough to enable him to comprehend the chemical economy of our globe, and the nature of those forms of matter with which we are most conversant.

Every advance in discovery carries our attention further and further from those substances with which we are most familiar. The elements of the ancients have long since been decomposed; and many of the substances into which they were separated, have been again and again subjected to the same process. If then we commence at the point where discovery has terminated, it is obvious that we immediately enter upon the consideration of objects perfectly new, and which, in fact, have no real, separate existence in nature, but are only found as the elements of other matter. As the science advances, then, we have to commence at greater distances from the ultimate purpose of our research, and to go through with an investigation of substances which have, in a certain sense, only an artificial existence, before we arrive at the consideration of those which it is our particular object to understand.

We think, then, that a general knowledge of the chemical constitution of bodies, and of the relations of the elementary substances to those compound forms of matter with which we are familiar among external objects, is best communicated by that method which it has been our object to recommend. The method proposed has also this excellence, which is of considerable importance, that it gives an immediate interest to the very commencement of the study; it awakens the curiosity and rouses the attention at once. We might be easily induced to listen to an account of the nature and composition of water, or of atmospheric air—substances with whose properties we are perfectly acquainted—when we should be completely indifferent about the history or description of oxygen, hydrogen, or azote—names, of which we had never heard. The student, at the outset, has no knowledge even of the existence of these bodies; and their properties are unlike those with which he has been usually conversant. He is obliged to obtain the subjects of his investigation by long and tedious processes; for they are seldom found in nature in a separate state; and it is only after a careful examination of their various combinations, that he understands the constitution of those substances with respect to which his curiosity is principally excited.

The fluctuating and progressive state of chemical knowledge is likewise an objection to the synthetic method of instruction. Till the science has been perfected, no arrangement can be adopted which will not be liable to constant variations, so long as new discoveries are made, and new views are taken of the ultimate composition of different species of matter. A complete and permanent arrangement upon this plan can be formed only when we know every thing within the limits to which human inquiry may extend, respecting the subjects about which it is employed. But this inconvenience, arising from the imperfection of our knowledge, is much less as it respects the opposite system. The forms of matter are always the same, although our views of their constitution may be constantly changing; and if they are taken as our guides, no changes in chemical theory can ever introduce confusion or disorder into a system founded upon this basis.

The first part of the work under consideration consists of five chapters, which treat of the general laws of the science, and of the powers concerned in the production of chemical phenomena. These powers are Attraction (including the attraction of cohesion, and chemical affinity) Caloric, Light, and Electricity, to each of which a chapter is devoted; and the fifth is occupied in a discussion of their general nature and mutual relations. We cannot pretend to give any abstract of the very valuable matter, relating to these difficult but interesting subjects. Modern researches have given us new views on most of the important points of theory with regard to them; and Dr. Gorham has collected a full and able account of the present state of our knowledge, and of the discoveries and improvements, which have made this one of the most curious and interesting departments of human science.

These changes have been principally brought about by the agency of electricity in chemical investigation; and the introduction of the Galvanic battery into the laboratory has formed an epoch in the history of the science, and given a new direction to the labours and studies of the chemist. The effects of this instrument are manifested in a variety of ways; in the production of an intense degree of heat in various bodies, violent shocks upon the human system, and a chemical decomposition of the most refractory substances; and these effects form some of the most wonderful exhibitions of the powers of matter which are afforded by human ingenuity.

When the voltaic apparatus, as it is usually denominated by chemists, is properly arranged,

'It will be found that the two extremities or poles are in opposite electrical states, the zinc always being positive and the copper always negative.'—'When the hands are well moistened and are brought into contact the one with the positive, the other with the negative pole, a shock will be experienced proportional to the number of plates; the shock from a battery of four hundred plates is exceedingly violent. If the wires be terminated by cones of dry charcoal, made from boxwood, on forming the communication, sparks will be produced, and part of the charcoal will become red hot. When pieces of this substance about an inch in length, and $\frac{1}{6}$ of an inch in diameter, were connected respectively with the positive and negative poles of the great battery of the Royal Institution, and brought very near each other, a bright spark was produced. and more than half the volume of the charcoal became ignited to whiteness, and, by withdrawing the points from each other, a constant discharge took place through the heated air, in a space equal at least to four inches, producing a most brilliant ascending arch of light, broad and conical in the middle.'

'The temperature excited in the circuit of batteries which are composed of a very large number of small plates, or of a small number of large plates is intensely high. The power to ignite bodies was almost equally apparent in a battery consisting of two thousand double plates, each exposing a surface of thirty two square inches, and in Mr. Children's arrangement, each triad exhibiting a surface of thirty two square feet. By the former, platina, one of the most infusible of bodies, was melted in the arch of flame as readily as wax in the flame of a common candle; quartz, the sapphire, magnesia and lime, all entered into fusion, fragments of diamond, and points of plumbago and charcoal rapidly disappeared and seemed to evaporate. By the latter 8½ feet of platina wire 0.44 of an inch thick were heated red hot; in small quantities it became bright red and melted at the ends; some of the most refractory oxides were reduced, and the most difficultly fusible metals melted into globules. The metals when reduced to very thin leaves do not require for their ignition or combustion that the power should be very high. Gold and silver leaf may be consumed, the one giving forth a brilliant yellow, the other a beautiful greenish white light, by connecting them with the poles of a battery composed of 100 double plates of three or four inches.

'The chemical effects of the voltaic apparatus are wonderful. Its operation is gradual, but continued, and no form of matter if compounded is able to resist its action. Compounds in the liquid state are decomposed with facility; but even insoluble compounds and the hardest and most solid aggregates are finally resolved into their elements by the decomposing power of voltaic electricity.' pp. 178—180.

By the introduction of wires of gold or platinum, connected with the two poles of the battery, into a vessel of water, this fluid is immediately decomposed, and its elements extricated, the oxygen being disengaged from the zinc or positive pole, and the hydrogen from the copper or negative; and this will take place when the distance of the wires through the water amounts to three feet. If, instead of these metals, those be employed which have a strong attraction for oxygen, the hydrogen only will be liberated, the oxygen combining with the metal; and on the other hand, if some other of the metals be employed, tellurium for example, no hydrogen is evolved at the negative extremity of the battery, but oxygen only, at the positive, whilst the appearance of the metal is changed, and it is believed that a compound is formed of hydrogen with the metal, which may be called a hydruret. By a similar arrangement, many other substances may be decomposed, as ammonia, the mineral acids, the metallic and neutral salts; and in all these cases the elements evolved correspond to the known composition of the substance subjected to experiment.

In the decomposition of these substances, the acid is always separated at the positive, and the alkali or metal at the negative end of the battery; and this, even under the most unfavourable circumstances for the production of such effects.

'Thus if three cups of agate or of gold be connected with the apparatus, the middle being filled with a solution of sulphate of potash, and the two others with pure water, and they be connected with each other by moistened amianthus, it will be found after a time, that the cup positively electrified will contain sulphuric acid, and the cup negatively electrified, potash, although no traces of either of these substances could be perceived in the water previous to the experiment. If the two extreme cups be filled with an infusion of red cabbage instead of water, the portion connected with the zinc end of the battery will become red, and that united with the copper end will be changed to a green; effects which are produced respectively by acids and alkalies.

'So powerful is this apparent attraction of acids to the positive end, and of alkalies or bases to the negative pole, that in passing to the respective extremities of the battery, it was proved by Sir H. Davy, that they might be made to proceed through, without combining with, substances, which in ordinary circumstances exert strong affinities. Thus when solution of sulphate of potash was put into the cup connected with the negative end, liquid ammonia into the middle cup, and pure water in the cup in which was immersed the wire from the positive surface, on completing the circuit, and allowing the apparatus to remain in that state for some time, sulphuric acid was found in the water; when the order was inverted, the sulphate of potash being in the positive cup, acid in the middle, and water in the negative cup, the base of the salt, or potash, was discovered in the water. In the first instance, therefore, acid matter was transmitted through ammonia, and in the second, alkaline matter or potash passed through an acid, without chemical union, notwithstanding the particles had freedom of motion, and are known to possess strong mutual affinities. By the same arrangements, acids and alkalies may be made to pass through coloured vegetable infusions without producing their characteristic effects.' pp. 185, 186.

The results obtained by means of the voltaic apparatus, and the great influence which this form of electricity was thus found to possess, in modifying and even neutralizing chemical affinities, suggested to Sir Humphry Davy the idea of attempting, by the same means, the decomposition of the fixed alkalies; and the consequence was one of the greatest discoveries of modern science. These substances had been supposed to be compounds; but there had been no well grounded opinion formed with respect to the nature of their ultimate composition. By subjecting them, however, to the influence of a powerful battery, oxygen was given off at the positive pole, and at the negative were observed small globules of a metallic lustre, resembling mercury, which combined rapidly with oxygen, if exposed to it in any of its forms, and reproduced the pure alkali. By employing substances, into whose composition oxygen did not enter, to receive and contain the results of his experiments, this great chemist was enabled to obtain for observation quantities of the new metal; which was thus proved to be the base of the alkalies; and potash and soda to be consequently of the class of oxides. This discovery was easily extended; and partly by actual experiment, and partly by analogical reasoning, it has been concluded, that the alkaline and other earths are similarly constituted; that they are all oxides, resembling in composition those bodies acknowledged to be such, and having the same chemical relations and powers. Their bases have accordingly been ranked in the class of metals, with names, such as potassium, barium, &c. derived from those of their oxides, and corresponding in etymological structure to those of the other metals.

Much of the history of voltaic electricity, as applied to the operations of chemistry, and indeed many other of the investigations of modern chemists, have thrown considerable doubt on the prevalent opinions, respecting the nature and agencies of the powers by which the operations of nature are carried on. The causes of what we call the effects of caloric, of light and electricity are generally believed to be fluids, unconfinable and imponderable, tending to diffuse themselves through space, capable of being transmitted from one substance to another, and of being accumulated in some bodies, and diminished in others, according to their several capacities, or the influence of a variety of circumstances. The theoretical speculations of philosophers have commonly proceeded upon this assumption; and it has not been long, that different opinions have attained any considerable currency. Such a belief is, however, at variance with many well known facts, and has been relinquished by some of the most distinguished chemists. It is not a great while, since the mechanical phenomena of the universe were explained upon a similar hypothesis ; and gravity like heat was supposed to be an all pervading fluid. Even within a few years, a similar doctrine has been hinted at with regard to magnetism ; and it is obvious, that explanations might be given of chemical attraction or affinity upon the same principle. But such hypotheses are now relinquished as chimerical. Gravity and affinity are believed to be the result of certain properties or powers of matter, by which it is enabled to maintain certain relations, and the phenomena of magnetism, notwithstanding the exception to which we have just alluded, are now generally accounted for upon a similar principle. But the old method of explanation, has, for no satisfactory reason that we can perceive, been retained with respect to heat, light and electricity ;—and their operations have been supposed to be performed by the interference of a specific sort of matter.

Yet where is the necessity of this interference of subtile and imponderable fluids ? Does it in fact explain the phenomena in question any better than they can be explained without it ? And if not, is it not unphilosophical, gratuitously to suppose their existence ? There has always been in the early stages of science, a great deal of this sort of philosophizing, which removes the difficulty it cannot solve one step further off. How are the questions to be answered, when we come to inquire, by what agents the revolutions of those subtile and imponderable fluids are effected, and by what causes they are made to perform the various offices assigned to them ? The fact is, nothing is gained by these assumptions ; one after another may be made without end. There have been some speculations with regard to electricity, which have introduced no less than two or three different modifications of each of the two opposite fluids, upon which its phenomena were imagined to depend. As science becomes more refined and genuine, such doctrines are rejected ; and we have no doubt, when the laws of chemistry are as well understood as those of other branches of physical science, that its speculations will be as little encumbered by the relicks of former hypotheses.

It may, perhaps, be thought that we consider the subject too curiously; but we really conceive that analogies sufficiently close exist between these different powers, to make it worth inquiry whether they are not all to be explained upon similar principles. To take caloric for example, do not its laws and those of gravitation resemble one another in many striking particulars? All the mechanical motions of the universe, we take it for granted, depend upon the power of gravitation, acting under different modifications and in different directions. The momentum acquired by a falling body is an accumulation of this power—as it may acquire an accumulation of caloric by percussion, friction, &c.—and it will produce motion in another substance, or raise the opposite scale of the balance, in the former case; as in the latter it will raise the mercury in the thermometer. The accumulated power of motion, like caloric, is also communicable, and tends to an equilibrium. If a body fall against the earth or some other fixed substance which is unelastic, its motion is destroyed; as a heated body is quenched at once in a large quantity of water. But if on the other hand it impinge against a small moveable body, its power is partly transferred, and both bodies move on with a force exactly proportional to their size and quantity of matter. How nearly does this resemble the laws of the distribution of heat. If, however, the substance against which another falls be elastic, the moving body rebounds. The direction of the power on which its motion depends *appears to be* changed or reflected, for the body itself is reflected from the elastic, precisely as light or heat is from a polished surface. We may find also without difficulty an arrangement by which we may produce an effect upon the gravitating power of matter, similar to that by which the light and heat of a large surface are concentrated in a single point. If we suppose a cone made to rest upon its apex, its whole weight is collected at that point. Now, in this case, the gravitating power of every particle out of the axis of the cone, is made to operate in a different direction from that in which it naturally would—i. e. towards the centre of the earth—and to assume a tendency towards the apex of the cone, as parallel rays of light or heat are collected in one point by the intervention of a lens, or the reflection of a mirror.

The analogy between the laws of these powers of matter appears to us at least sufficient to render it probable that their nature is similar, and that if the phenomena of the one can be consistently explained without the intervention of any separate and specific material principle, those of the other may be also. But although we readily admit the probable immateriality of caloric, yet we cannot subscribe to the detailed explanation of this doctrine which has been advanced by Sir H. Davy.

'It is assumed,' says Dr. Gorham in his account of this theory, 'that in solids the phenomenon of heat results from a vibratory or undulatory motion of their particles, the temperature varying with the spaces between them, and the intensity of the vibrations; that in liquids and gravitating elastic fluids, the vibration is accompanied with a motion of the particles around their own axis, those of gaseous matter being performed with the greatest velocity; and that in etherial fluids or radiant matter, the particles move around their own axes, and separate from each other, penetrating in right lines into space. Temperature may be conceived to depend upon the velocity of the vibrations; increase of capacity upon the motions being performed in greater space; and the diminution of temperature during the conversion of solids into liquids or gases upon the idea of the loss of vibratory motion, in consequence of the revolutions of the particles upon their own axes, at the moment when the body becomes liquid, or aëriform, or from the lessened rapidity of vibration, from the motions being performed in a greater space.' p. 216.

Now all this is purely hypothetical; it could not from the nature of the subject be otherwise; and it is besides somewhat obscure. We are not called upon to enter so deeply into the hidden processes of nature. If we can render it probable, that the supposition of the existence of a peculiar species of matter is without foundation, we are not therefore obliged to show how things can be managed without it. The burden of proof lies upon the opposite side. The production of high temperatures by percussion and friction, and also by chemical combinations and decompositions, in which there is no condensation, affords a principal argument against the material nature of heat. Yet this has no bearing upon the opinions of Sir Humphry Davy; but is simply of a negative character, tending merely to show that the received doctrines do not explain all the phenomena in question.

In considering the nature of caloric, we ought to throw out of view the relation it bears to our own sensations, which has in fact nothing to do with the question. These are immediately excited by a change in the state or actions of the extreme vessels, and not by any matter communicated from the heated body. The same sensations may be produced by substances of a temperature lower than that of the body, which have the power of exciting a similar action or change in these vessels. We refer to the operation of caustics.

Putting aside then the power of heated bodies upon our feelings, what other powers do they possess, by which they are distinguished from substances at the ordinary temperature of the atmosphere? The effect of a high degree of heat seems to be an increase of chemical energy, and an altered state of chemical affinity. If a piece of metal be heated to a certain degree, its tendency to combine with oxygen is augmented, and if it be exposed to the influence of the air it becomes an oxide. Here is a certain change produced in the chemical affinity of this substance; but at another degree of the thermometer, the same oxide which was thus formed becomes decomposed, and the metal is restored. Here is another change in its chemical affinity. We perceive changes in chemical affinity, and we perceive nothing more. Expose the same metal, at any temperature, however low, with which we are acquainted, to the action of nitric acid, and similar changes will take place. But in the last mentioned experiment, heat will be generated. The power, then, which produces the sensation of heat, may be considered merely as the result of the chemical state of certain bodies, of the action of their affinities, and not as a separate substance, the cause of that state and of the action of these affinities. Thus an electrical discharge, which is in itself possessed of no temperature, is capable of setting fire to an inflammable body;—that is to say, electricity, a powerful chemical agent, becomes the cause of a series of processes carried on in the combustible substance, in consequence of which, heat is generated. It is obvious, that upon the principles just stated, the sensible effects which take place in the common cases of combustion, are to be explained, not by the supposition of the extrication of caloric, a separate substance, but as produced, without any such intervention, by the chemical operations which are going forward.

The phenomena of light are certainly better explained upon the theory of radiant particles issuing from the luminous body, than those of caloric are, upon the material hypothesis. But we have no evidence of the existence and nature of light except by its immediate effects upon our senses. Light is only a power in external objects of affecting our organs, so as to produce certain sensations; and the same sensations may be produced in circumstances where there can be no possibility of the presence of radiant light; as in passing the shock of a Galvanic battery through the head, a flash is distinctly perceived. But whatever doubts there may be with regard to the existence of light, as a seperate substance, yet it must be confessed, that the subject is too little understood, to enable us to form any consistent and satisfactory hypothesis.

There seems till of late to have been little or no doubt among philosophers, that the phenomena of electricity were caused by the operation of a peculiar fluid or fluids, which pervaded all matter; and the respective theories of Dufay and Dr. Franklin, founded upon their several assumptions, have, one or the other, been received by all men of science. The principles of these theories are sufficiently familiar to most of us.

'But an hypothesis differing essentially from them has been stated by Sir Humphry Davy. Electricity is conceived by this distinguished chemist to result from the general powers or agencies of matter, and its phenomena to be displayed in the attractions and repulsions between different bodies or their particles. In these cases they assume a polar arrangement, and the opposite extremities are dissimilarly electrified, the positive pole of one being opposed to the negative pole of the other. The effect is proportional to the violence with which the electrically attractive and repellent powers are exerted, and may be connected with the motions of the particles of the substances affected. The difference in what has been called the conducting powers of bodies, seems to depend entirely upon the different manner in which they receive the electrical polarities, or in which their parts become capable of communicating attractive or repellent powers to other matter. When an excited body is brought into the neighbourhood of an insulated conductor, the air being interposed, the nearest point of the conductor becomes dissimilarly electrified, the remote extremity similarly electrified, and the middle is in a neutral state. The conductor here acquires polarity with ease, and exhibits but two poles, and this polarity is *induced* by the proximity of the electrified body. The polarities of the two bodies may continue to be exalted, until they are annihilated through the air, producing what is commonly called an electrical discharge. The phenomena of sparks, discharges, and accumulated electricity, depend upon this law. The particles of different bodies are also inferred to possess inherent, electrical energies, and it is considered as not improbable, that the same arrangements of matter, or the same attractive powers which place bodies in the relations of positive and negative, i. e. which render them attractive of each other electrically, and capable of communicating attractive powers to other matter, may likewise render their particles attractive, and enable them to combine when they have full freedom of motion. Hence electrical and chemical phenomena may depend upon the same power; in the former case acting upon masses, and in the latter upon the particles of matter.' p. 224, 225.

These principles, in general, appear to us to afford the best explanation of the phenomena of electricity; though the theory just stated is tinctured in a considerable degree by that fondness for minute and intricate specifications respecting the operations of nature, which is characteristic of the speculations of its celebrated author. There are many facts which tend to confirm the latter part of the passage just quoted, and to show the near connexion which exists between electricity and chemical affinity.

' Most of the substances, which act distinctly upon each other electrically, are such as act chemically when their particles have freedom of motion; this is the case with sulphur and the metals, with acid and alkaline substances; and the relations of bodies are uniform; those which have the highest attractive powers being in the relation of positive in arrangements in which chemical changes can go on.' p. 203.

'The connexion existing between electrical phenomena and chemical changes, is likewise evident in the general phenomena of the voltaic battery. The most powerful combinations are formed by substances that act chemically with most energy upon each other; and such substances as undergo no chemical change in the combination, exhibit no electrical powers.' p. 204.

These circumstances, and a variety of others which might be brought forward, lead almost inevitably to the conclusion, that electricity and chemical affinity are identical; that the phenomena attributed to them are the results of the same principle acting for different purposes and in different relations; and when viewed in connexion with other facts, afford likewise much ground for the belief, that heat, light and magnetism are also different exhibitions of the same cause, acting under various modifications, and producing different results, according to the nature of the substance which is operated on.

'An intimate connexion appears to subsist between electricity, light and caloric. As bodies require to be raised only to a certain temperature to become luminous, so it is only necessary that the electrical excitation should be increased to a certain point to render them radiant. The effect of lightning in setting fire to combustbles is well known. The electricity excited by friction will inflame combustible liquids, gun-powder and the metallic exploding compounds. Transmitted in large quantities through the perfect conductors, it melts and dissipates them in globules. The temperature produced in the circuit of the batteries of Mr. Children and of the Royal Institution of London, was probably equal or nearly so to that of the flame of the oxy-hydrogen blowpipe, which is the highest that can be effected by art. Electricity even of low intensity is accompanied with light. The spark is familiar, and the star which is sometimes observed stationary upon the point of a conductor is brilliant and well defined. A variety of bodies, when electrically excited, become phosphorent, and non-conductors subjected to friction are rendered luminous. The colour of the light is not always the same; it varies according to the intensity of the excitation, the distance to which it is to be transmitted, and the nature of the medium which opposes the action. In low degrees of excitation, the colour is red; in proportion as they are exalted, it becomes purplish, and when intense, white with a shade of violet.' p. 232, 233.

Wherever the electrical agency is supposed to operate with the greatest force, there light and heat are proportionally developed, as in the experiments related p. 179 of the work under review, of which we have given an account. Galvanism, as we have previously remarked, is capable of producing the sensation of a flash of light when the eyes are entirely closed; and the dry points of the wires connected with the extremities of the battery produce a feeling of heat in the skin, although their temperature is not raised. These powers of generating, as it would seem, light and caloric, by means of the electrical apparatus, lead to additional doubts of their material nature—for if material, whence is the immense and long continued supply derived in some of the operations of the galvanic battery? Or at least they imply, in all their phenomena, the operation of only common ultimate principles. For if it be argued in defence of the old hypothesis that the heat &c. thus developed, is caloric, set free by the chemical operations going on in the troughs of the battery, and which are probably necessary to its electrical powers—still, how is this caloric conveyed along the wires of the battery without raising their temperature, and brought into operation only, when their extremities are made to communicate?

As electricity produces heat, so too the variations of heat produce electricity. It is developed by changes of temperature and of form; by the cooling, for instance, of melted sulphur, by the production and condensation of vapour, and by heating certain mineral substances, which in their ordinary state exhibit no signs of electricity.

The light, which is a consequence of electrical operations, obeys the same laws as that of the sun, and is separable into the same elements by the prism. There is also a farther resemblance between the chemical powers of the different kinds of rays, into which the solar spectrum has been divided, and those of electricity. 'The rays at the red end, in their chemical powers, tend to burn bodies or combine them with oxygen; those at the opposite end tend to restore inflammability to bodies; and negative electricity, which exercises the same function, produces hydrogen gas from water, and the inflammable bases from their combinations.' In addition to all this, the influence which both light and electricity have in the production of magnetic power, points out another relation between them, and of both to that inscrutable principle on which the phenomena of magnetism depend. There is no doubt that they are both capable of communicating to iron, under certain circumstances, the polarity of the magnet.

Now what is the conclusion which most naturally follows from all these facts? Is it not this—that the phenomena of affinity, caloric, light, electricity and magnetism are all equally the consequences of certain laws of matter, by which the intimate constitution of substances is maintained, and their chemical revolutions effected; which operate in these different ways and produce such various results, according to the circumstances of the operation, the nature of the bodies operated upon, and the nature of the substances which are the recipients of the effects? Thus if the stream of galvanic power be made to pass through a wire of platina, intense heat is produced; if through a quantity of water, a solution of a neutral salt, or some other compound substance, the result is a chemical decomposition; if the subject be a thin metallic leaf, an opposite effect is produced, and the metal combines with oxygen. In some substances, friction is capable of producing an intense degree of heat; in others an excitation of electricity. These are a few exemplifications of this principle, but many others have occurred in the course of our remarks.

The second part of this work relates to the properties and relations of ponderable bodies, &c. They are divided by Dr. Gorham into the organized and unorganized, the former including those substances which are, or have been, parts of some living system; the latter, the inert mass of common matter. The same elements, however, enter into the composition of both, although they are combined by different laws, and for different purposes. The elementary substances described amount to fifty two, but the existence of a few of these is somewhat hypothetical; and the number is continually varying with the progress of discovery; since it is one of the first principles of the science, that every substance is to be regarded as simple till proved to be a compound.

The elementary substances are arranged by Dr. Gorham under three classes; 1. Supporters of Combustion containing four, 2d. Inflammable or acidifiable unmetallic bases containing seven, and 3d, Metals containing forty one individual species. The two first classes only are described in the present volume. Under the sections relating to the several elements, are included accounts of the principal combinations which they form with each other.

Lavoisier founded his system of chemistry principally upon the relations, which oxygen was supposed to bear to the other elementary bodies; the influence it exerted in combustion; and upon the properties of those substances of which it formed a component part. It was believed to be the only supporter of combustion, and the principle on which the acids, whose composition was then known, depended for their peculiar properties. At the time this theory was promulgated, it was almost without exception applicable to the phenomena to which it related; and modern discovery has not so much tended to prove that its doctrines are false, as to narrow the limits within which they are to be applied. It has in the first place brought to light other supporters of combustion besides oxygen; or to speak more accurately, other elementary substances analogous to oxygen in most of their properties. In fact, neither of the substances included in this class is absolutely necessary to combustion; for, according to modern views, its phenomena are merely the consequence of intense energy of combination. If substances with strong chemical affinities combine, there is often an evolution of heat and light, whether any of the supporters be present or not. Some of the inflammable bodies themselves in their turn become fully as much supporters of combustion, as chlorine or iodine. There is a gas lately discovered called cyanogen, the basis of the celebrated prussic acid, composed of 46.78 carbon and 53.22 azote, which is capable both of being inflamed itself, and of supporting combustion in other substances. When kindled, it burns with a bluish flame, producing azote and carbonic acid; but if potassium be introduced into it, and heated, the metal takes fire and burns also with flame. The case is similar with respect to sulphuretted hydrogen. Though inflammable itself, it supports combustion in potassium, which will take fire in it and burn with great brilliancy. Unless the definition of combustion be confined within the limits of Lavoisier, there are no particular elements that we can distinctly class together as supporters of that process. Still there are sufficient analogies between the substances thus classed together in the present work, to authorize their arrangement in the same division; although there may be some doubt about giving them the distinctive title of supporters of combustion.

The views of the old theory respecting the constitution of the acids, were still more partial. It is generally believed by modern philosophers, that hydrogen, as well as oxygen, is capable of acting as an acidifying principle, when combined with a base; and that all those substances called supporters of combustion, form acids in union with hydrogen, except oxygen, and thus act both as bases and acidifying principles under different circumstances. Yet we cannot perceive why it should be concluded, when an acid is produced by the combination of hydrogen with chlorine or iodine, that the former should be looked upon as the principle of acidification instead of the latter. We do not recollect any acid of very marked properties, in which the acidifying principle may not be supposed to be one of the supporters of combustion, with as much reason as hydrogen. But it does not seem to be necessary to conclude that acidification is dependent upon any particular principle, any more than combustion. It may be merely the consequence of a particular mode of union, and of some hidden analogies of constitution, which have hitherto eluded investigation.

A new modification of the theory of acidification has been lately advanced, which owes its origin to Dr. Coxe of Philadelphia, was adopted to a certain degree by Davy, and has been finally matured and presented to the world by Dr. Murray. Water has always appeared essential to the constitution of the stronger acids, and they have never been obtained in what was to be considered a dry state. But it may be, that the elements of the water do not enter into the composition of the acid as water, but as oxygen and hydrogen; and the reason why dry acid cannot be obtained is, that no such thing can exist; and all the water has been separated, which is separable without the decomposition of the acid.

> 'It is conceived by Dr. Murray that from the united action of the elements, viz. oxygen and hydrogen, a higher degree of acidity is acquired, than from the influence of either of them alone; and sulphur is quoted as affording a striking example. With hydrogen it forms a weak acid (*sulphuretted hydrogen*). With oxygen it also forms an acid, (*sulphurous acid,*) which though of superior energy, still does not display much power. With hydrogen and oxygen, it seems to receive the acidifying influence of both, and its acid (*sulphuric acid*) is proportionally exalted.' p. 525.

Similar views may be taken of the compounds of nitrogen and of carbon; and there seem to be strong grounds for the opinions which Dr. Murray advances. He has extended the same theory to the subject of the alkalies.

> 'As hydrogen in some cases gives rise to acidity, so it may in other cases occasion alkalinity. Under this point of view ammonia, in which oxygen cannot be detected, is a compound of which nitrogen is the base, deriving its alkaline power from hydrogen; it stands therefore in the same relation to the other alkalies, that

sulphuretted hydrogen does to the acids. The fixed alkalies, potash and soda, are considered as hydrates, that is to say, as bases united chemically with a certain proportion of water, but it is obvious, says Dr. Murray, that the elements of the water may exist in combination with the base; that potash, for example, is not a compound of oxide of potassium with water, but of potassium, oxygen and hydrogen.' p. 531, 532.

As a consequence of these views, the constitution of the neutral salts must be different from what is commonly supposed.

'Neutralization is not the saturation of acid with alkali, and the subversion of the properties of one by the opposed action of those of the other; but is the change of composition of both, and the quiescence of the elements in that proportion in which their affinities are in a state of equilibrium without any excess.'

'All these results display more fully the extensive relations of the two elements, oxygen and hydrogen. They do not act merely in opposition, as has been imagined, but more frequently in union, producing similar effects. Hydrogen is of nearly equal importance with oxygen, and the principal details of chemistry consist in their modified action on inflammable, and metallic bodies.' p. 533.

In examining a system of chemistry of recent date, we cannot but be astonished at the accumulation of facts which has been made within the present century. Indeed, that part of the volume before us which relates to the details of the science, seems almost wholly occupied in the narration of new discoveries. As has been before observed, three substances are now classed with oxygen as supporters of combustion—chlorine, formerly the oxymuriatic acid; iodine, an entirely new substance strongly resembling chlorine; and fluorine, the supposed base of the fluoric acid, and bearing the same relation to it that chlorine does to the muriatic. To the class of simple inflammable bases, not metallic, two new substances have been added, boron and silicon. The former combined with oxygen forms the boracic acid, whose composition was unknown in the days of Lavoisier; the latter is the base of silex, and is found to resemble more nearly this class of elements, than the earths with which it was formerly arranged. The alkalies and earths have been decomposed and proved to be metallic oxides; and a new alkali and a new earth have been added to the number of those formerly known to exist.

To enter into any account of the various compounds which have been brought to light, and can be formed from these various elements, would be at once useless and uninteresting. Yet it is worth while to state that out of about forty, described in the present volume, at least one half are of very recent discovery, and of these the greater proportion are artificial or invented—if we may use the expression—that is, not existing in nature, but put together by the ingenuity or good fortune of the chemist.

Yet, notwithstanding all the brilliant discoveries, and the important truths which have graced the progress of modern chemistry, it is difficult to avoid regretting the overthrow of so simple and beautiful a system as that of Lavoisier. It is impossible for those of us, who have formed our ideas of the chemical operations of nature on the principles which he taught, to turn with complacency from a theory like his to a state of science so unsettled and so obscure, as modern chemistry now is. That the progress of discovery has most unquestionably overthrown the foundations of the old theory, we cannot doubt; yet it has substituted nothing in its room; and the science consists now in an immense mass of facts without any regular and consistent connexion. This, from the nature of the thing, is inevitable; and our chemists must leave to their successors the task of arrangement and generalization. They have torn down but have not built up. They have overthrown the works of Lavoisier, and yet there seems to be scarcely any thing certain in speculative chemistry, except what remains of his theory. And after all, he who desires only to understand the chemical constitution and operations of nature, will find them better explained and more easily understood upon the principles of the old school. Not that we would undervalue the alterations and discoveries of our own times; they are a natural consequence of the advanced state of the science, and lead to its ultimate perfection. Yet they have made it less captivating to the general scholar; they have lessened the interest with which it is viewed by those not immediately engaged in its pursuits, by rendering it more complicated and more difficult to be understood, and less applicable as a whole to the explication of those phenomena of the natural world with which we are most familiar.

Chemistry has hardly received, in our own country, that attention which its real importance, and intimate connexion with our national prospects and improvement, would seem to demand. The contributions which this science has made to the arts, the improvements it has suggested in many important manufactures, and above all the security it has given to the lives of thousands by means of the celebrated safety-lamp of Sir H. Davy, prove how much an enlightened and well directed philosophy may do to improve the condition of mankind. This consideration gives it a high claim to the attention of a nation like ours, and yet we have but few men among us, who have made it their profession to understand and teach it; and it is only to such that we can look for any important accessions of knowledge. Chemistry has become in Europe almost a separate profession; and we consider it as a most desirable event to have men of abilities and enterprize, devoted to it from inclination, who are at leisure to to give themselves up wholly to its pursuit; and who are not obliged to labour in other occupations for a support, whilst the cultivation of their favourite study is only their relaxation and amusement. When we have such men among us, then and not till then shall we be able to contribute our full share to the science of the world; and to turn to the best account the various means which chemistry affords for the improvement of our own condition.

The length to which we have extended this article, as well as the particular remarks which we have had occasion to make on the character of the work under review, are sufficient proofs that we estimate it highly. We regard it, as far as it has yet been published, as one of the best introductions to the science with which we are acquainted. We look forward with interest to the publication of the second volume.

ART. IX.—*Travels in Canada and the United States in* 1816 *and* 1817. *By Lieut. Francis Hall.* 8vo. pp. 332. Boston, Wells & Lilly, 1818.

THE writer of this volume is an English officer, who appears to possess an open, candid disposition, with some pretensions to taste and literature. He has good sense enough to think, that a country is not to be judged by its